Space Weather Technical Forecast

Issued on Wednesday, 22 March 2023 at 01:20 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-class flares. G1-G2 Minor/Moderate storms likely day 2 (23rd) with coronal hole enhancement and possible CME arrivals. Active Electron fluence likely by day 4 (25th).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low with the largest flare an impulsive C4.5 at 21/1353 UTC from AR3257 in the southeast disc. There are six sunspot regions on the disc, five of which are numbered. The most complex is AR3257 which has maintained a delta spot ahead of its largest main spot, albeit weak. The other southeastern spots include AR3256, which has continued to see trailer spots weaken, and AR3259 which is a small but stable region. A new spot is also rotating over the southeast limb that remains unnumbered. AR3260 in the northeast has also remained stable, whilst AR3261 in the southwest has weakened since its emergence yesterday.

There are a number of filaments on the Earth-facing disc, and these have been the source of a few CMEs when they lift. These have generally been off the Earth-Sun line with no Earth-directed CMEs observed in the last 24 hours. However a mixture of SOHO manoeuvres and STEREO A being used for non-operational activity results in limited availability of imagery, and low confidence for the CME analysis.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured at L1 showed the arrival of the fast wind of CH85/+. This rose from around 400km/s to peak at elevated levels of 500-550 km/s by the end of the period. The density remained at average levels. The total IMF strength Bt, was weak to moderate, between 7-11nT with the north-south component, Bz ranging from -8 to +11 nT, but more often pointed in a positive direction (northward). The phi angle remained predominately positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES-16 is slightly above background, but well below the S1 Minor Radiation Storm Level, and easing. The high energy electron flux (greater than 2MeV) has generally been Background to Moderate with peak flux of 428 pfu. The associated 24-hour Electron fluence remained below the Active (1e8 integrated pfu) threshold. At 22/0000 UTC the observed fluence was 7.57e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Generally Low Solar activity is expected, with a chance of isolated Moderate flares. The main flare risk is currently from the more complex region in the southeast disc, AR3257, or from any of the regions rotating onto the disc form the far-side.

Solar Wind / Geomagnetic Activity: The CME as a result of the coronal dimming off the southwest disc on the 20 March has a low chance of glancing Earth early on day 2 (23rd). A second CME from the northeast filament eruption on the 20 March may give a glancing arrival around midday on day 2. Otherwise current elevated winds from CH85 are expected to ease slightly day 1 (22nd) before a transition into a stronger fast wind region from CH86/- day 2

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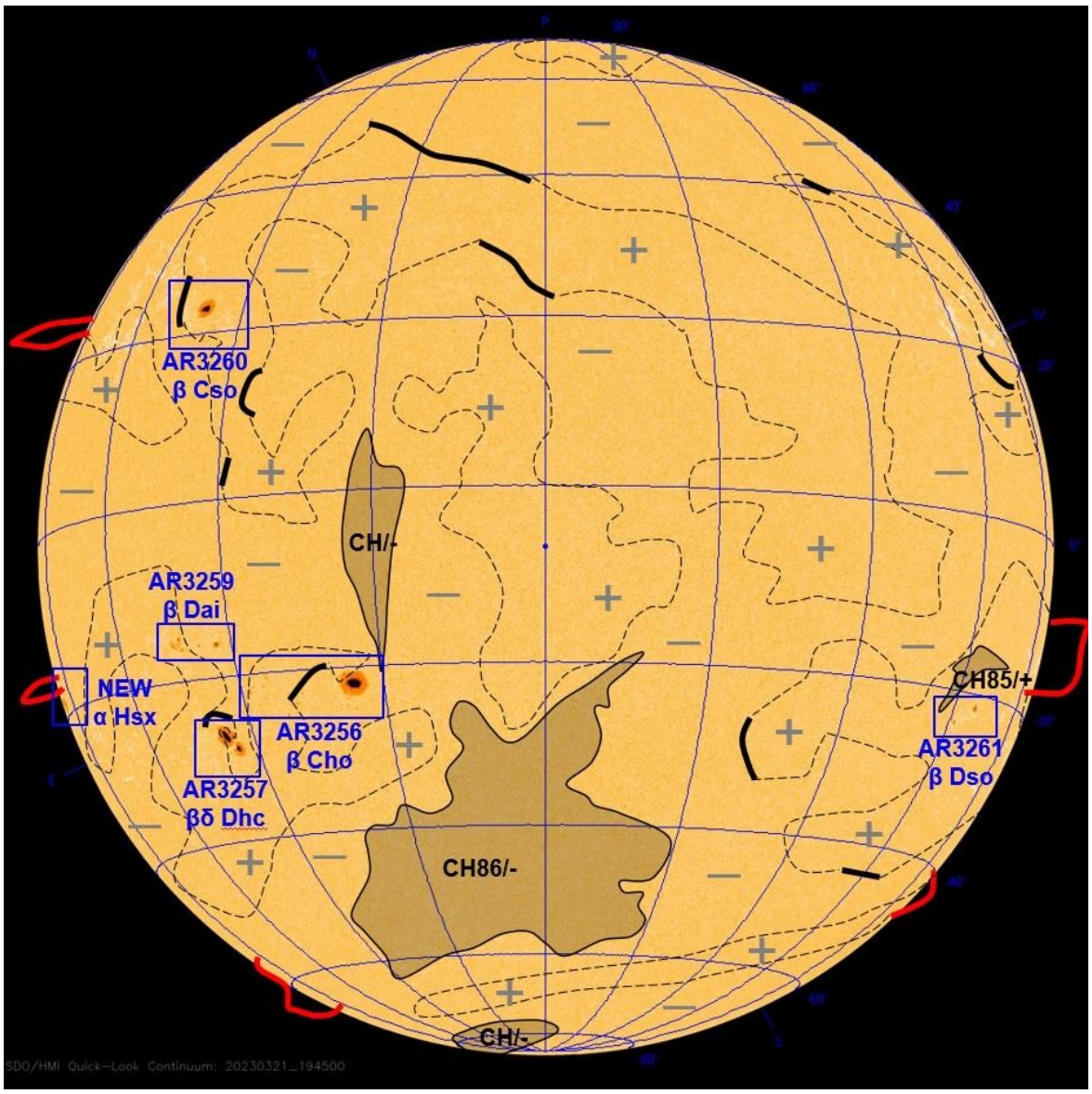
(23rd), potentially preceded by a notable CIR region. These elevated winds are expected to continue day 3 (24th), perhaps easing day 4 (25th). Geomagnetic activity is expected to be Quiet with Unsettled intervals for much of day 1, increasing to Unsettled to Active, with G1/Minor Storm intervals likely day 2 due to the combination of CH and CME effects. Activity gradually easing day 3 and 4, to be mainly Quiet with isolated Unsettled intervals by the end of the period.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to decline to background, albeit erratically, with only a very slight chance of further enhancements given any significant flares occur. The high energy (greater than 2 MeV) electron flux is expected to persist largely at background days 1 to 2 (22nd-23rd) before likely rising day 3 (24th) to Moderate and then High by day 4 (25th). The associated 24 hour fluence is expected to remain below the Active threshold for much of the period, but with a chance of rising above day 4.

Figure 1. Solar Analysis Valid 21/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two CMEs that may give a glancing impacts at Earth, however these assessments carry low confidence due to the reduced imagery as a result of both SOHO LASCO and STEREO A having reduced operational availability.

The first was observed on the 20th, leaving the SW disc as a result of a broad coronal reconfiguration. The signal in coronagraph imagery was weak resulting in low confidence in analysis, but has chance of giving a glancing impact during the early hours of day 2 (23rd). The second is from a filament eruption in the northwest disc on the 20th, forecast to reach Earth's orbit around midday on day 2 (23rd). Minimal impact is expected, with much of the material passing north and behind Earth.

Current elevated solar winds, due to CH85/+ fast winds are expected to ease slightly day 1 (22nd). CH86/- is then expected to follow this, most likely on day 3 (23rd). As a persistent and clearly defined feature, a strong enhancement is expected, with winds reaching 600-700 km/s, and likely preceded by a relatively strong CIR region. These fast winds are then expected to persist into day 3 (24th), only easing day 4 (25th).

Geomagnetic activity is expected to be Quiet with Unsettled intervals for much of day 1 (22nd). During day 2 (23rd), the combined effect of CME arrivals and CH86/- enhancement is expected to increase activity to Unsettled to Active, with G1/Minor Storm intervals likely. There is a slight chance of G2/Moderate storms, should these CME and coronal hole sources enhancements align. Any enhanced winds are expected to continue day 3 (24th), but gradually easing back to mainly Quiet with isolated Unsettled intervals by day 4 (25th)

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	70	40	5
Strong	G3	No	1	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/0810	Partial	Coronal Dimming	SW	602	23/0100	Limited shock with glancing impact. Low confidence.
20/1905	Partial	Filament Eruption	NE	815	23/1100	Glancing impact. Low confidence.

Figure 2: Enlil and Ensemble showing potential arrival timing. This is dependent upon the CH connection to CH86, which Enlil currently isn't modelling in-line with forecast expectation.

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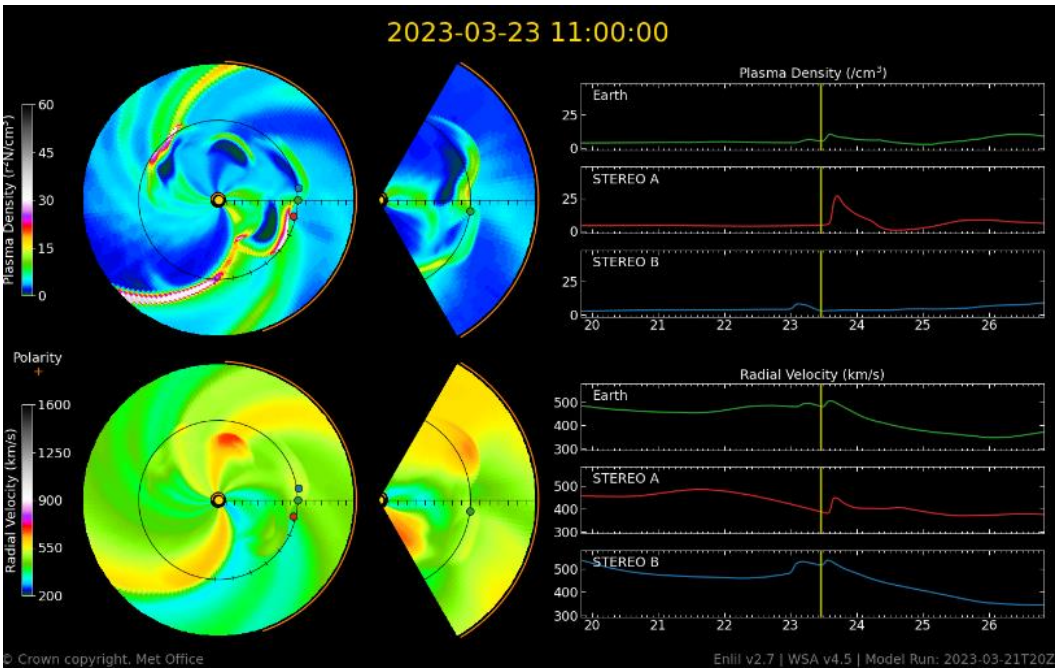

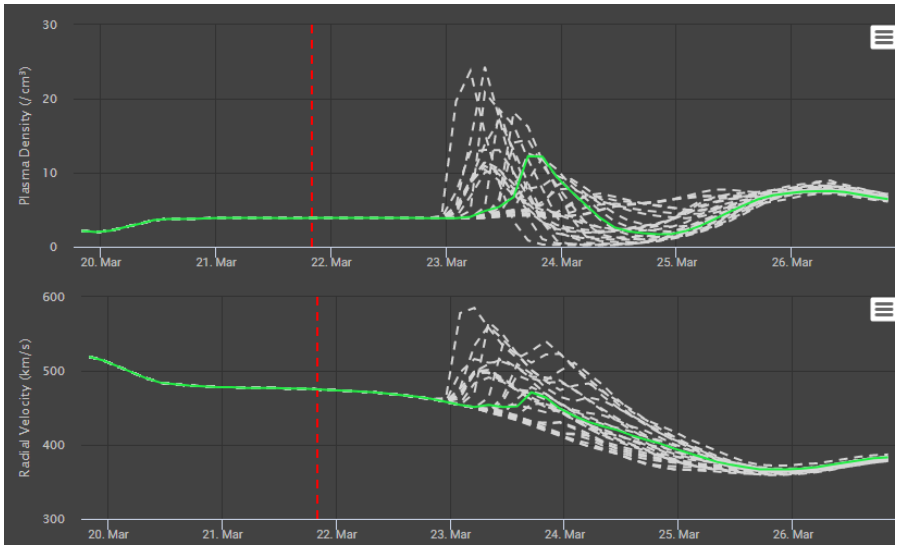

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Radio Blackouts - X-Ray Flares:

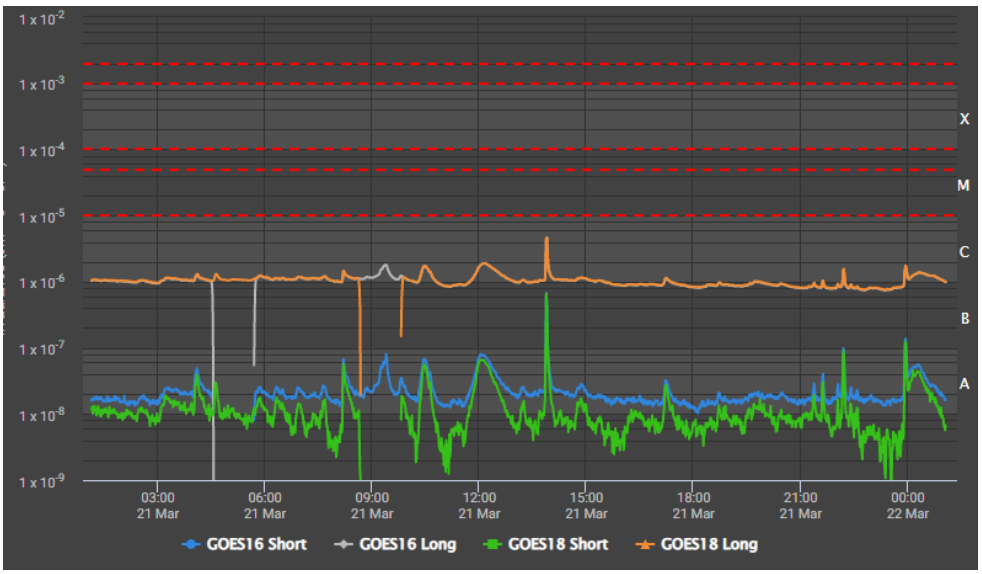
Generally Low Solar activity is expected, with a chance of rising to Moderate with isolated M-flares.

There are six sunspot regions on the disc, five of which are currently numbered, with a further region rotating onto the southeast disc. Of the spots currently on the disc, AR3257 in the southeast is the most likely source of notable flares, consisting of two main negative umbras, but with a nearby small positive polarity regions resulting in a very weak delta spot. AR3256, also in the southeast has continued to weaken, now largely dominated by a single strong negative leader spot, but still with small trailer spots. The other spots are all either stable or decaying and generally magnetically simple.

The new region in the southeast has some associated looping visible on SDO imagery and bright flux on STEREO A euvi that suggests further complexity can be expected to rotate onto the disc, following this region. A similar bright looping and flux signal is also present on the northeast limb, suggestive of a further region likely to rotate onto the disc here. Either of these increase the potential for significant flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16/18 X-ray Flux



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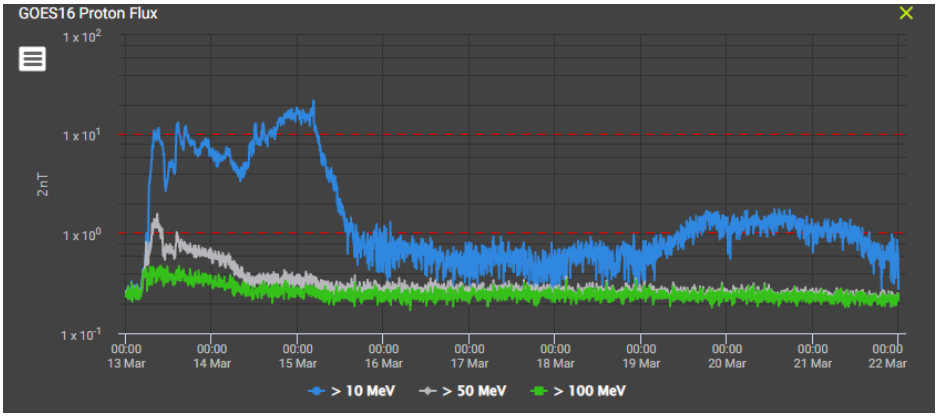
Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES-16 is currently slightly above background as it continues to erratically decline from the S1 Minor Radiation storm event triggered by the large far-sided eruption that occurred on the 13th March. There is a very slight chance of further enhancements, due to the increased flare risk from the sunspot groups in the eastern disc. While not favoured for a strong connection, any significant flares will bring a slight chance of flux levels rising towards the S1 Minor Radiation storm level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 >10MeV, >50MeV and >100 MeV Proton Flux since 13th March



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High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2MeV) electron flux observed by GOES-16 is expected to be mainly background to Moderate days 1 and 2 (21st and 22nd) with any enhancement from the fast wind arrival of CH85 likely to be limited. A more significant enhancement is expected from CH86 on day 3 (23rd). Coupled with potential CME arrivals, this will initially result in a dropout of values, before flux likely rises later that day, or more likely through day 3 (24th). By day 4 (25th) High levels are likely.

The associated 24 hour fluence is expected to be below the Active (1e8 integrate pfu) level through days 1-2 (22nd and 23rd) with REFM currently giving good guidance for this period. Fluence levels are then expected to rise through day 3 (24th), likely reaching the Active levels day 4 (25th).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	30	60
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	5

Figure 5: GOES-16 >2MeV Electron flux and associated fluence with REFM.

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